RESEARCH REPORT

Seed Plant Illustrations in Biology Textbooks

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Educational Materials Research and Development Section

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Seed plants are vascular plants that have roots, stems, leaves, and seeds. They comprise the vast majority of land plants and are man's principal sources of food, clothing, and shelter (potato, cotton, and oak plants, for example). Since trees, flowering plants, grasses, and "weeds" are all seed plants, most people are not familiar with any other kind of plant.

The study reported herein follows a textbook analysis design. Its goal is a compilation of those illustrations directly pertinent to seed plants which commonly appear in high school biology texts. It is designed primarily as a reference source for developers of tangible aids in biological science for the visually handicapped.

Method

A. Textbooks

If tangible aids are to be developed in accordance with the findings of a textbook analysis, it is important to employ the textbooks used by the target population. The American Printing House for the Blind (APH, the official U.S. schoolbook printery for visually impaired students) currently publishes two biology textbooks. Each of these texts were analyzed in this study along with two additional representative textbooks. These latter books were included to increase the probability of obtaining the most commonly occurring, and hopefully, most important seed plant illustrations.

The following textbooks were analyzed in this study:

A. Modern Biology, Holt, Rinehart, and Winston, Inc., 1965 (APH, 1960 copyright, braille and large type)

B. Biological Science, Harcourt, Brace, and World, Inc., 1968 (APH, braille and large type)

C. Biology, Addison - Wesley Pub. Co., 1969

D. Exploring Biology, Harcourt, Brace, and World, Inc., 1966

The Modern Biology text analyzed is less dated than the APH publication; however, it was found to contain illustrations identical (majority of cases) or very similar to those in the APH-produced textbook.

B. Subject Criteria

Seed plants are characterized by their common utilization of seeds in reproduction and inclusion in one of two plant classes: Gymnospermae or Angiospermae. Illustrations employing seed plants range from those of a universal plant nature to those uniquely illustrating seed plant characteristics. Since seed plants, for themselves, are the object of this analysis, only illustrations of seed plant structure and/or function (life processes) have been included in this study.

Excluded from this analysis were illustrations utilizing seed plants in the demonstration of heredity, classification system, ecology, and evolution, when these topics were treated in a general sense. However, when such topics were discussed (and illustrated) in their specific application to seed plants, these topics were retained. For example, seed plants were often used in illustrations of the classification of all living things. In

a number of instances it did not appear that classification, per se, was of main import, but rather, the characteristics of each class. All such illustrations of gymnosperms and angiosperms were therefore included in the analysis.

C. Illustration Criteria

Illustration criteria determine which nonverbal textbook presentations will be considered for inclusion in this study, as well as the form that an entry will take. In the pages to follow, lists of illustrations are presented. Certain rules were followed in compiling them and only certain representations qualified as "illustrations."

An illustration consisted of a picture, drawing, or diagram. In the latter case, it was required that at least 50% of the diagram be in picture or drawing form. Strictly verbal diagrams, then, were not allowed.

The determination of "one" illustration was seldom a problem. Most every illustration encountered was accompanied by a combination chapter-position figure number, such as 14 - 2 (2nd figure of chapter 14). Each illustration and its page number was recorded as a unit for future reference. Where two or more identified figures appeared on the same page, two or more entries were recorded.

Infrequently a number of individual illustrations appeared on a page without separate figural identification. Identification was made by reference to subtitles or general section headings. In such cases each individual illustration was nominally recorded along with others within a single entry for that page.

The particular verbal form of an entry depended primarily upon the main intent of the illustration as best interpreted by the researcher following figure captions and textual references. This form usually consisted ofan abbreviated statement of illustration content along with a parenthetical designation of the involved seed plant (name) or the context in which the illustration appeared (if not presented in and for itself). This procedure allows apparatus developers the knowledge of which plants are used to illustrate particular plant functions or structures.

Conservation of verbal forms was observed. Whenever an illustration was judged to be essentially the same as a previously recorded one, it was identically recorded. If an illustration was found to contain basically the same content as previous recordings but with additional or deleted material, it was recorded in as similar form as possible with noted differences.

Results

Tables 1, 2, 3, and 4 present the results of the textbook analyses described above. Each table represents the data collected from one of the four texts analyzed. Page numbers of the various entries have been included for reference sake in case of a need for additional information. The order of tabular presentation of illustrations and their textual occurrence coincide.

TABLE 1

Seed Plant Illustrations in Modern Biology

Page	Entry
303	Gymnosperms (Cycads)
304	Fruit-enclosed angiosperm seed (Bean) versus exposed gymnosperm seed (Pine)
305	Ginkgo tree and exposed seed-bearing structures (a gymnosperm)
306	Conifers (Loblolly Pines) have leaves in the form of needles or small scales
307	External anatomy of a flowering plant (Bean)
310	Magnified photograph of xylem tissue showing vessels and tracheids (Ash)
310	First and second years' growth of a biennial (Foxglove)
313	Primary and secondary roots
314	Fibrous root system versus taproot system (Grass, Beet)
314	Long section of a root tip showing growing zones
315	Numerosity of root hairs on a root (Radish Seedling)
315	Development of a root hair from an epidermal cell
316	Cross section of a root (Buttercup)
317	Cross and longitudinal sections of a root illustrating respective tissue location (Carrot)
318	Knees (Bald Cypress)
319	Types of adventitious roots: climbing (Ivy), brace (Corn), tip layering (Raspberry)
320	Absorption of water by root hairs and successive osmosis
321	Turgor
322	Geotropism (experiment)
323	Hydrotropism (experiment)
326	External anatomy of a woody stem
327	Type of branching in a tree depends on the arrangement of the buds: opposite or alternate
328	Long section of a bud-the growing point of a stem
329	Excurrent branching
330	Deliquescent branching (Elm)
331	Cross section of a three-year-old woody dicot stem
332	Cross section of a three-year-old woody dicot stem (Linden)
333	Photomicrograph of spring and summer cells (annual ring)
334	Annual rings of a trunk
335	Cross and longitudinal sections of a monocot stem (Corn) and a herbaceous dicot stem (Bean)
336	Four types of underground stems: bulb (Onion), tuber (Potato), corm (Crocus), rhizome (Iris)
337	Budding (mechanical) and grafting
338	Capillarity experiment

TABLE 1 (Continued)

Page	Entry
342	Types of leaf venation and compounding: Palmate, pinnate, and parallel venation; simple and compound leaves (Oak, Sycamore, Redbud, Elm, Corn, Rose, Pea, Clover, Horse Chestnut, Honey Locust)
343	Cross section of a leaf (including vein)
344	Lower leaf epidermis, stoma, and guard cells
345	Cross sections of a shaded and unshaded leaf
346	Adaptation of leaves for capturing insects (Venus's Flytrap)
347	Abscission layer between petiole-stem junction
349	Transpiration (experiment)
353	Parts of a typical flower
354	Various patterns of attachment of ovules to ovary (Peach, Geranium, Pea)
355	Stages in pollen and ovule formation
357	Pollination by insects (bee)
358	Development of the pollen tube and sperm nuclei from a pollen grain and structure of the female gametophyte (pollination to fertilization; Peach)
361	Methods of seed dispersal in various plants (Witch-Hazel, Touch-Me-Not, Maple, Wafer Ash, Linden, "Sticktights," Spanish Needles, Burdock, Sweet Cicely, Dandelion, Sycamore, Milkweed)
363	Internal and external anatomy of a bean seed (reproduction)
363	Internal and external anatomy of a corn seed (reproduction)
364	Types of dry fruits: pod (Lima), capsule (Iris), samara (Maple), grain (Corn), nut (Oak), achene (Sunflower)
365	Types of fleshy fruits: pome (Pear, Apple), berry (Tomato, Grape), drupe (Avocado, Cherry), accessory (Strawberry, Raspberry)
367	Germination of a bean seed into a seedling
368	Germination of a corn seed into a seedling

TABLE 2

Seed Plant Illustrations in Biological Science

Page	Entry
262	Reconstruction of a primitive vascular plant, showing tissues and structures similar to those in present day vascular plants (Rhynia-extinct)
263	A primitive vascular plant (Psilotum)
263	Illustration of the two principal leaf types among vascular plants: single vein (Lycopodium and many veins (Ginkgo)
264	Diagrammatic summary of two different theories of single-veined leaf evolution
264	Two living representatives of primitive vascular plants (Lycopodium, Equisetum)
265	Principal steps in the evolution of a many-veined leaf (theory)
266	Primitive arrangement of vascular tissue in roots and advanced arrangement of vascular tissue in stems (Both, cross sections)
268	Steps in seed evolution (partially theoretical)
269	Parts of a typical flower
270	Steps in the evolution of a fruit around developing ovules (theoretical)
273	Structure of the female gametophyte (pollination to fertilization)
275	Diagram illustrating the increasing specialization of the sporophyte and decreasing specialization of the gametophyte in seed plants (evolutionary trend; Alga, Fern)
280	External anatomy of a leaf
281	Cross section of a leaf (including vein) with route diagram of photosynthetic reactants going into and out of it
282	Illustration of the selective absorption of light by chlorophyll (experiment)
286	Lower leaf epidermis, stoma, and guard cells
297	External anatomy of a herbaceous plant shoot
297	Cross and pie section of a stem (Sunflower)
298	Conducting cells of xylem (tracheids and vessels) and phloem (sieve tube)
300	Cross section of a woody stem
301	Principal root systems: fibrous (Grass) and taproot (Beet)
302	Cross section of a root (Buttercup)
303	External anatomy of a root and root hair cells (development)
305	Experiment demonstrating the dynamics of the upward movement of water in a plant

TABLE 2 (Continued)

Page	Entry
307	Illustration of the absorption, upward movement, and transpiration of water in a plant
310	Illustration of asexual reproduction by vegetative propagation (Potato, Banana, Forsythia, and Bryophyllum)
312	Detailed life cycle of a typical flowering plant (flower to seedling)
314	Anatomy of a bean and corn seed (reproduction)
315	Illustration of various kinds of flowers as well as monocot and dicot floral characteristics (Butterfly Bush, Easter Lily, Passion Flower)
316	Comparison of dicots and monocots through their respective seeds, leaves, flowers, and cross sections of stems
318	Experiment demonstrating comparative regions of growth in a root (Bean Seedling)
319	Longitudinal sections of a root tip and a stem tip showing parallel growth regions
320	Cross sections of a stem (longitudinal section) at various intervals from its tip showing increasing structural complexity
321	Response to touch (Mimosa Pudica)
323	Experiment illustrating the effect of different photoperiods on flowering (Maryland Mammoth Tobacco)
324	Experiment illustrating the induction of flowering by exposing one of two grafted plants to short-day conditions (Maryland Mammoth Tobacco; florigen)
325	Experiment illustrating the inhibition of flowering by preventing (girdle cut) florigen (set free by proper photoperiods) in one grafted plant, from reaching the other grafted plant, which has not been exposed to sufficient light periods for "flowering" (Cocklebur)
769	Illustrations of the class Gymnospermae (Ginkgo branch, fossil Ginkgo leaf, Ginkgo trees, Monkey Puzzle tree)
770	Illustrations of the class Gymnospermae, continued (Douglas Fir and Western Cedar, fossil sprig and cone of an extinct species of Sequoia, fossil trunk of Sequoia)
771	Illustrations of the class Gymnospermae, continued (White Pine branch, White Pine tree, fossil trunk sections [Araucarioxylon], fossil cones [Proaraucaria], close-up of Cycad cones, Cycad
772	Illustrations of the class Angiospermae, subclass Monocotyledoneae (Bamboo, Banana tree, Winter Wheat)

TABLE 2 (Continued)

Page	Entry
773	Illustrations of the class Angiospermae, subclass Monocotyledoneae, continued (Skunk Cabbage, Narcissus, Fan Palm, fossil leaf of Fan Palm, Wild Grass, young Corn plant, Lily)
774	Illustrations of the class Angiospermae, subclass Dicotyledoneae (Waratah, Bunchberry, fossil Sycamore leaf, Trollius-a primitive flowering plant, Sycamore tree)
775	Illustrations of the class Angiospermae, subclass Dicotyledoneae, continued (fossil Walnut, Black Walnut tree, fossil Acorn, White Oak tree, White Oak branch, fossil Oak leaf)

TABLE 3

Seed Plant Illustrations in Biology

Page	Entry
72	Structure of the female gametophyte (pollination to fertilization)
73	Gymnosperms (Cycad, Spruce, Ginkgo)
74	Male and female Pine cones
75	Germination of a seed into a seedling (Bean)
75	A dicot has two cotyledons (Bean) while a monocot has only one (Corn)
76	Comparison of dicots and monocots through their respective seeds, leaves, flowers, and cross sections of stems
198	Permanent tissues in adult plants: xylem, phloem (conducting); leaf epidermis, cork (protective); parenchyma, sclerenchyma, collenchyma (fundamental)
199	Pie section of a woody stem
276	Van Helmont's experiment showing origin of materials used in photosynthesis
291	Anatomy of a seed (Bean, Corn)
292	Germination of a seed into a seedling (Bean)
293	Cross section of a woody stem
293	Cross section of a woody stem showing concentric cylinders of tissue in relief
294	Lenticels of a young woody stem
294	Long section of a stem tip showing growing zones
295	Cross section of a monocot stem showing typical scatter of xylem and phloem (Corn)
295	Cross section of a root
296	Root hair in its relationship with the immediate physical environment
297	Long section of root tip showing growing zones
297	Net-veined dicot leaves and parallel-veined monocot leaves
298	Cross section of a leaf
298	Lower leaf epidermis, stoma, and guard cells
304	Illustration of the absorption, upward movement and transpiration of water in a plant
307	Geotropism (experiment)
307	Germination of a grass seed into a seedling, focusing on the coleoptile (phototropism)
308	Illustration of Darwin's phototropic experiments (Grass)
308	Illustration of another phototropic experiment by Darwin (Grass)
309	Illustration of Boysen-Jensen's phototropic experiments (Grass)
309	Illustration of other phototropic experiments by Boysen-Jensen (Grass)

TABLE 3 (Continued)

Page	Entry
310	Illustration of Went's phototropic experiments (Grass)
310	Illustration of other phototropic experiments by Went (Grass)
311	Illustration of further phototropic experiments by Went (Grass)
312	Treated (with Auxin) and untreated plant cuttings showing root formation only in the former
313	Increasing amounts of gibberelin were applied to grapes with the result of increasing grape size
316	"Flowering" experiment using two grafted plants (Cocklebur)
317	"Flowering" experiment in which plants were exposed to different light conditions (Kalanchoe)
320	Flowers vary considerably in morphological appearance (Rose, Pussy Willow Catkin, Flower of Indian Grass)
320	Parts of a typical flower
321	Self-pollination and cross-pollination
322	Anatomy of a pollen grain and its germinating structure
322	Structure of the female gametophyte (pollination to fertilization)
323	Methods of seed dispersal in various plants (Touch-me-not, Maple, Sticktight, Dandelion, Pear, Coconut, Cocklebur, Raspberry, Witch Hazel)
324	Life cycle of a typical flowering plant
467	Open and closed (with fly inside) Venus's Flytraps (plant sensitivity)
501	Vegatative reproduction by "runners" (Strawberry)

TABLE 4

Seed Plant Illustrations in Exploring Biology

Page	Entry
88	Plant, leaves, and parts (longitudinal section) of a flower (life processes; Wild Rose)
89	Cross sections of a root and woody stem (life processes-absorption; annual rings)
90	Seed-making in a flowering plant-pollination to fertilization in female gametophyte (life processes-reproduction)
140	A primitive vascular plant (Psilopsid)
141	Anatomy of a seed (Bean)
142	Comparison of monocot (Corn) and dicot (Bean) plants, leaves and seed leaves
144	Anatomy of a naked seed and its arrangement in a cone (Pine)
145	A gymnosperm (Cycad)
147	Gymnosperms (Ginkgo, Pine)
148	Angiosperms, subclass Monocotyledonae (Corn, Lily, Palm, Lady's Slipper)
149	Angiosperms, subclass Dicotyledonae (Poplar, Birch, Buttercup, Rose, Giant Suguaro, Tobacco, Sunflower)
267	Long section of a young root tip showing regions and structures
268	Development and growth of a root hair
269	Development of xylem vessels
270	Constituents of phloem
271	Germination of a seed into a seedling (Bean)
272	Cross section of a woody dicot stem (Basswood) versus that of a herbaceous monocot stem (Corn)
277	Absorption of water by root hairs and sucessive osmosis
279	The path of water in transpiration
281	Lower leaf epidermis, open and closed stoma, and guard cells
284	Cross section of a typical leaf (including vein)
288a	Illustration of types of seed plants: gymnosperm (White Pine) and two angiosperms-a monocot (Corn) and a dicot (Buttercup)
288b	External anatomy of a gymnosperm, male and female Pine cones, cross sections of a needle, stem and root (White Pine)
288c	Longitudinal sections of a male cone (bearing pollen sacs) and a female cone (after pollination), scale of female cone after pollination but before fertilization, mature seed released by female cone, young seedling, cross section of pollen (White Pine)

TABLE 4 (Continued)

Page	Entry
288d	External anatomy of a monocot plant, cross sections of a leaf, stem, and root (Corn)
288e	Stamens on a tassel, pistillate flower, pollen on silks, ovaries with silks, young seedling (Corn)
288f	External anatomy of a dicot plant, cross sections of a leaf (including vein), stem, root, and fibrovascular bundle in stem (Buttercup)
288g	Parts of a dicot flower, longitudinal section of pistil after pollination, cross section of a seed, and anatomy of a seedling (Buttercup)
288h	Methods of pollination: self-pollination (Garden Pea), insect pollination (bee on Clover), pollination by wind or falling from stamens (Corn)
291	Phototropism and geotropism (experiment)
487	Asexual reproduction by runners (Strawberry)
488	Budding and grafting
490	Longitudinal section of an Apple blossom (reproductive structures)
491	Staminate and pistillate flowers (Corn)
492	Structure of the female gametophyte (pollination to fertilization)
494	Anatomy of a Bean and Corn seed (reproduction)

In their present form the above tables are almost too cumbersome to be useful. Their entries are too numerous and unorganized to project a clear indication of their relative importance. Table 5 has been developed to overcome these shortcomings. It lists only those entries which commonly occur in a number of the analysis tables. If an entry appeared in three or more texts, or in both of the texts produced by APH, then it was included in this list of important illustrations.

TABLE 5

Commonly Occurring Seed Plant Illustrations

ABCD*

1. Cross Section of a leaf (4 Anon.)
2. Lower leaf epidermis, stoma, guard cells (4 Anon.)
3. Longitudinal section of a flower (3 Anon., Apple)
4. Long section of a root tip showing growth zones (4 Anon.)
5. Structure of the female gametophyte - pollination to fertilization (4 Anon.) with a) illustration of pollen granule germination included (2 Anon.) or b) contained in a separate figure (Anon.) [D lacks "a" and "b"]
6. Phloem and xylem tissue [xylem only, in A] (4 Anon., 1 Ash-xylem only)
7. Cross section of a woody stem (6 Anon., Linden)
8. Cross section of a root (2 Buttercup, 2 Anon.)
9. Anatomy of a bean and corn seed [seed, reproduction] (5 Bean, 4 Corn)
10. Monocots and dicots

Plants (ABD)

M: 6 Corn (1 from # 18), 2 Lily, Skunk Cabbage, Narcissus, Fan Palm, Wild Grass, Bamboo, Banana, Winter Wheat, Palm, Lady's Slipper
D: 4 Buttercup, 2 Bean (1 from # 18), Waratah, Bunchberry, Sycamore, Trollius, Black Walnut, White Oak, Poplar, Birch, Rose, Tobacco, Sunflower, Giant Saguaro

Seeds (ABCD)

M: 6 Corn (4 from # 9), 2 Anon.
D: 6 Bean (4 from # 9), 2 Anon., Buttercup

Leaves (BCD)

M: 3 Anon., Corn
D: 3 Anon., Bean

Flowers (BCD; dicot only in D)

M: 2 Anon., Easter Lily
D: 2 Anon., Buttercup, Passion Flower

Cross sections of stems (ABCD)

M: 4 Corn, 2 Anon.
D: 2 Anon., Bean, Buttercup, Basswood

11. Gymnosperms (4 Ginkgo, 4 Cycad)

TABLE 5 (Continued)

12. Asexual reproduction [budding and grafting only, in A] (2 Strawberry, 2 Anon., Potato, Banana, Forsythia, Bryophyllum)
13. Route of water in transpiration process (4 Anon.) [transpiration and capillarity experiment only, in A (2 Anon.)]
14. Leaf venation (6 Anon., Corn, Bean - all from # 10; 2 Anon., Oak, Sycamore, Redbud, Elm, Rose, Pea, Clover, Horse Chestnut, Honey Locust, Ginkgo, Lycopodium, Corn)

ABC

15. Long section of a stem tip showing growth zones [labeled parts only, in A] (3 Anon.)

ABD

16. Development of root hairs from root epidermal cells (3 Anon.)

ACD

17. Root hairs and absorption (3 Anon., Radish Seedling)
18. Germination of a seed into a seedling (4 Bean, Corn)
19. Geotropism experiment (3 Anon.)
20. Types of pollination (2 Anon., Pea, Corn, Clover)

AB

21. Principal root systems: fibrous (2 Grass) and taproot (2 Beet)

* Textbook designation by letters are:
A - Modern Biology (APH)
B - Biological Science, An Inquiry into Life (APH)
C - Biology, Introduction to Life
D - Exploring Biology

Table 5 is arranged in the order of decreasing importance of illustration entries. Criteria of importance are the number and type of books which contain the illustration in question. The greater the number of textbooks in which a given illustration occurs and its occurrence in an APH - produced text, in that order, are the criteria of an illustration's importance. Entries have been cat-

egorized under letter symbol headings which serve to identify the textbooks in which they commonly occur (see note in Table 5). In order of decreasing importance, then, the possible categories under which an entry was placed are ABCD, ABC and ABD, ACD, and AB (no listed BCD entry). Again, Table 5 parenthetically indicates the plants involved in the entries.

A very few number of illustrations (involving corn and bean) were found to illustrate more than one of the 21 entries of Table 5. Where this occurred an indication of borrowing has been made.

Entry No. 10 is a special case among the other entries. Included here are illustrations which compare monocots to dicots and illustrations which describe the characteristics of one or the other cotyledonous plant. These latter illustrations most often occur in pairs (one monocot and one dicot illustration) in close textual proximity, and it has been assumed that a comparative connotation prevails. The only condition wherein a monocot or dicot illustration was excluded from this entry was where an occurrence appeared in isolation (from a comparison plant) and lacked an indication of the number of cotyledons present.

The kinds and number of plants used in the important illustrations of Table 5 should be of interest to the materials developer. One hundred and seventy-nine different plant illustrations occur in Table 5, seventy-six of which utilize anonymous plant examples. Specific plants occurring five times or more often are: Corn (18), Bean (14), Buttercup(9), and Ginkgo (5).

Despite the more frequent overall occurrence of corn plants, it should be noted that bean plants are used four times as often (#18-4 Bean, 1 Corn) to illustrate the growth and development of typical seed plants. In addition, it is notable that these two plants are the ones used most frequently in the comparison of monocot and dicot characteristics (#10).

Discussion

This analysis has uncovered 21 important seed plant illustrations. A principal concern of materials developers in initiating this study was the determination of about one half dozen illustrations appropriate for the introduction of higher plants. Once specified, these illustrations could be developed into models of a plant kit.

Introductory models should concentrate on simple educational tasks and contents like the identification of plant parts, and avoid those concepts which demand higher levels of intellectual development as in the understanding of the processes of transpiration and fertilization. In order to isolate these basic illustrations, the 21 important illustrations were divided into three classifications based on complexity level. Each was found to be primarily concerned with either plant structure, plant function, or abstract qualities of plants. Illustrations of structure show the various physical parts of a plant; illustrations of function demonstrate life processes; and illustrations of abstract qualities illustrate intangible calssifications (types of venation, root systems, etc.). The 21 illustrations have been classified into these three categories in Table 6 where the cardinal numbers associated with the entries of Table 5 are sub-

stituted for their complete descriptions.

TABLE 6

Classification of Table 5 Entries by Complexity Level

Complexity Levels	Entries
I. Structure	1, 2, 3, 4, 6, 7, 8, 9, 15
II. Function	5, 12, 13, 16, 17, 18, 19
III. Abstract Quality	10, 11, 14, 20, 21

Of the three complexity levels shown in Table 6, the structural level appears to be most fundamental. Illustrations of structure simply identify component plant parts while those of function and abstract quality describe complex processes and abstract relationships. The former illustrations (structure) are the most elementary and are demanded as prerequisites on which to build the latter ones (function and abstract quality). These structural illustrations, then, should comprise the list of introductory illustrations desired.

Nine entries are classified at this complexity level. However, entry # 6 is identical to parts of entries # 7 and # 8, so that it may be deleted as a separate illustration without educational consequences. Entry # 15 has great conceptual similarity to # 4 and may also be deleted without fear of loss of concept attainment. These latter two entries are so similar that a teacher could easily illustrate both concepts with the more popular entry (#4) using few qualifications. With the incorporation of these entries, seven illustrations remain that are most appropriate for inclusion in an

introductory plant models kit (#'s 1, 2, 3, 4, 7, 8, and 9).

Although it would be expected, these seven entries do, in fact, correspond to the structural parts of a seed plant: leaves, flowers, roots, stems, and seeds. However, if illustrated individually without an overall frame of reference, a full understanding of their interrelationship may go uncomprehended. Therefore, it is recommended that a model of an adult plant should be added to the list of introductory illustrations. The importance of such a model is attested to by entries #18 and #10 (plants) of Table 5.

Root hairs (#'s 16 and 17) have been classified under function since their illustrative representations are oriented to this end. However, it would make good sense to be sure they are shown in models of root tip zones (#4) since they do comprise an important part of the morphological plant.

Analysis of the Manual of Biology Diagrams produced by APH for the visually impaired confirms the importance of the seven selected entries. Although considerably dated (1959, and therefore a limited criterion) it is the product of educators and does wield some authority. Table 7 is a list of raised line drawings constituting the manual section dealing with higher plant anatomy.

TABLE 7

Anatomy of the Higher Plants
from the Manual of Biology Diagrams

Entries
1. Epidermal Tissue of a Plant and Typical Plant Cell Enlarged (no comparable illustrations of tissue and plant cells were excluded from this analysis)
*2. Epidermal Cells of a Leaf (#2)
*3. Cross Section of a Leaf (#1)
*4. Conducting and Supporting Cells in Wood (partially covered in #6)
5. Root Hair Cells (#'s 16 and 17)
*6. Anatomy of a Root Tip - Showing Principal Zones (#4)
7. Pollen Grain - Showing Development of the Pollen Tube (#5)
*8. Stamen of a Flower (covered in #3)
*9. Longitudinal Section of a Flower (#3)

Included in Table 7 are indications of entries which also occur in Table 5 (parenthesied) and those which have representation in the structural level of complexity of Table 6 (starred). Discounting entry #1, 6 of the 8 remaining entries of Table 7 pertain to 5 (allowing #6) of the important structural illustrations (#'s 1, 2, 3, 4, and 6). This additional confirmation of the majority of selected structural illustrations by the Manual of Biology Diagrams lends an extra degree of confidence to the selection which has been made for model development through textbook analysis and educational prerogatives.

If and when post-introductory plant models are developed, it is suggested that an alternate plan to the function-abstract quality design be followed with regard to the remaining entries. This researcher feels that a comparative emphasis has been given to all

facets of monocot-dicot structural differences and that models should be developed which compare their respective characteristics. The complexity of entry #10 attests to this fact and entries #14 and #21 could be summoned to serve on their behalf.

The remaining entries illustrate plant function and should be developed as a group (#'s [5, 20], 12, 13 [16, 17], 18, 19). Bracketed illustrations could be consolidated to eliminate overlap and conserve model usage.

Entry #11, Gymnosperms, is the only remaining illustration of Table 5 unaccounted-for. Though belonging to the important seed plant group, they were characteristically subordinated to angiosperms and were never used (with few exceptions) to illustrate plant structure, function, or abstract qualities of plants. Their typical employment was in the illustration of the gymnosperm classification. These illustrative deficiencies have led to their elimination as candidates for model illustration.

Summary

A textbook analysis of representative biology texts for the determination of important seed plant illustrations was undertaken. Twenty-one illustrations were isolated based upon their repeated appearance in a number of the texts, especially those produced at APH. Demands of materials developers for a list of about 6 to 8 important illustrations to be developed into an introductory plant models kit led to a three-way classification of the generated illustrations corresponding to their level of complexity. Illustrations

primarily concerned with plant structure were determined to be elementary and constituted the prerequisites for the understanding of illustrations demonstrating plant function and abstract qualities of plants. Eight illustrations of plant structure were finally recommended for materials developers, five of which are endorsed by their presence in a currently produced, raised line drawing, biology manual for the visually impaired.

References

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